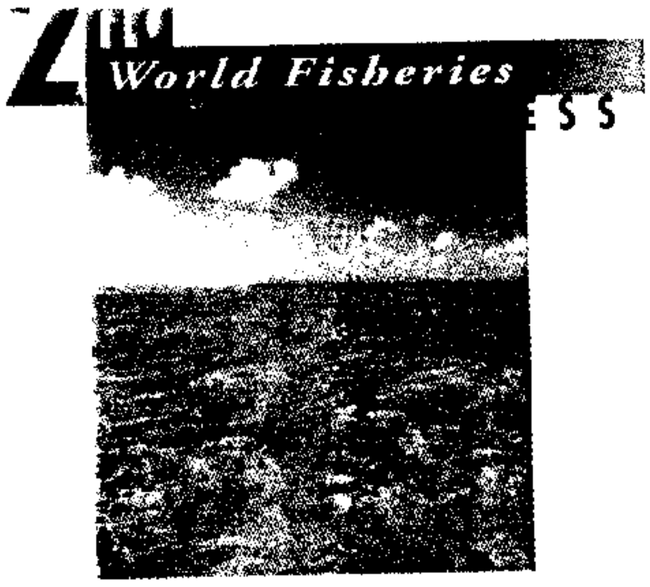

BYCATCH IN THE GULF OF MEXICO SHRIMP FISHERY

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Summary

Over the past five years a total of 3653 observer days have been secured by shrimp bycatch observers in the Gulf of Mexico and along the east coast of the United States of America. Analysis revealed that on average about 27 kg of organisms per hour are taken during trawling operations in the Gulf of Mexico. Examination of the composition of the organisms revealed that about 68% of the catch by weight is composed of finfish (mostly groundfish), 16% by commercial shrimp species, 13% by non-commercial shrimp crustaceans and 3% by non-crustacean invertebrates.

Although groundfish species make up the majority of the bycatch taken in shrimp trawls, three species (king mackerel, *Scomberomorus cavalla*, Spanish mackerel, *S. maculatus*, and red snapper, *Lutjanus campechanus*) have received a great deal of attention because of their commercial and recreational importance and the potential for significant impacts on their population abundance through shrimp trawling activities. Average catch of these three species is generally below 0.5 kg per hour

INTRODUCTION

The incidental harvest of non-target species or bycatch by the US Gulf of Mexico shrimp fishery is a controversial and volatile issue. The principal gear used in this fishery is the otter-trawl, a relatively non-selective bottom-trawl that catches a variety of finfish and invertebrate species. Many of these species are released dead, injured or stressed. Conservation agencies and environmental organizations generally view shrimping as a destructive or wasteful fishery that negatively impacts many other living marine resources (Fowle and Bierce 1992).

Bycatch in the shrimp fishery has long been a topic of concern (Lindner 1936). Information on species composition of shrimp fleet discards in the Gulf of Mexico has been documented by several studies (Hildebrand 1954; Bullis and Carpenter 1968; Moore *et al.* 1970; Bryan and Cody 1975; Chittenden and McEachran 1975; Drummond 1976; Pavella 1977; Warren 1981; Bryan *et al.* 1982; Nichols *et al.* 1987; Powers *et al.* 1987). Although shrimp trawl bycatch has been identified as a potential problem for over sixty years, little has been accomplished in reducing or eliminating bycatch. Despite numerous attempts to utilize bycatch, shrimp trawlers continue to discard several t of finfish each year.

In recent years, the Gulf of Mexico shrimp fishery has experienced increased scrutiny regarding the impacts of trawl bycatch on natural resources. Shrimp fishery bycatch discards in the Gulf of Mexico have been estimated at several billion fish per year, with most of the catch composed of groundfish such as croaker, seatrout, porgies and spot (Nichols *et al.* 1990). In addition to the once abundant stocks of groundfish that have suffered reduction over the past few decades, many other species are transient or temporary residents on the shrimp grounds and are captured in shrimp trawls at certain times of the year or during certain life stages. Although these species may represent only a minor component of the total bycatch, their losses may have significant adverse effects on their population abundances. Excessive bycatch in shrimp trawls has been suggested as the primary cause for declines in stocks of some commercially important finfish, endangered sea turtles and other living resources in the Gulf of Mexico (Henwood and Stuntz 1987; Goodyear and Phares 1990; Caillouet *et al.* 1991; Goodyear 1991; Alverson *et al.* 1994).

As one of the largest and most valuable US fisheries (National Marine Fisheries Service Fisheries Statistics Division 1994), the shrimp industry could be severely altered and impacted if effective solutions to the bycatch problem are not found. Additionally, major long-term harvest reductions could be imposed on other important commercial and recreational fisheries targeting finfish species affected by shrimp trawler bycatch. While these actions would be required to protect and in some cases rebuild affected fish populations, their implementation would not be without economic and social disruptions to those fisheries.

In February 1992, a joint commercial/government research programme was initiated between the National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) and the Gulf and South Atlantic Fisheries Development Foundation, Inc. (Foundation) to collect species-specific bycatch data to characterize catch rates by number and weight taken by the shrimp fishery during commercial operations in the US Gulf of Mexico. The goals of this joint research programme were to: (1) update bycatch estimates temporally and spatially, (2) manage and maintain bycatch characterization data sets, (3) analyse bycatch characterization data on the temporal and spatial catch rates of finfish and shrimp, and (4) provide data to estimate total bycatch of selected species for stock assessment analysis. This research effort provides essential data to Southeast Regional Office (SERO), Gulf and South Atlantic Fishery Management Councils, fish and wildlife departments of Gulf and south Atlantic states, associations of commercial shrimpers and recreational fishermen, and legislators and elected officials at all levels of government. This paper provides a general overview of the results from this ongoing research programme.

MATERIALS AND METHODS

The sampling design used in this research effort follows the guidelines as set forth in the Research Plan Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries, prepared by the Foundation, under the direction of a Steering Committee composed of individuals representing industry, environmental, state and Federal interests (Hoar *et al.* 1992). The intent of the sampling design was to survey the shrimp fishery during commercial operations and not to simply establish a research survey study of the bycatch or the finfish populations. The sampling universe consisted of all tows from all vessels shrimping in the Gulf of Mexico. Parameters of interest were the catch totals and size distributions of bycatch species of finfish and invertebrates incidentally taken by the shrimp fleet.

The quantity and type of bycatch differ with fishing location, season, depth, trawl type and turtle excluder device (TED) type. Stratification by each of these variables will tend to minimize the variances of catch estimates. The use of trawl and TED types as stratification variables, however, was impossible since this information was not available '*a priori*'. Thus, only location, season and depth can effectively be used as stratification variables. Twenty-four stratification strata were identified using three seasons (pre-summer: January through April, summer: May through August, and post-summer: September through December), four locations (Florida, Alabama-Mississippi, Louisiana, and Texas), and two depth zones (nearshore, ≤10 fm; and offshore, >10 fm). The sample unit consisted of a single subsample from a trawl haul.

NMFS-trained observers were used to collect the trawl haul subsamples and record the data from the fishery. A subsample was obtained from a randomly-selected net after each tow. The data collected consisted of tow weight, species composition, species abundance, species weight and length measurements by species groups. Preliminary research tows indicated that a subsample of 13 kg per towing hour was adequate to ensure that most species taken in the catch were adequately represented in the subsample. A detailed description of the on-board sampling procedures is contained in the NMFS Bycatch Characterization Sampling Protocol (Galveston Laboratory 1992). All observers, whether funded by NMFS or through the Foundation, were required to collect data following this protocol. To further standardize the data collection methods, observers from the various programmes were required to successfully complete a five-day training workshop established during the first year of the bycatch research programme.

Statistical analysis of the data from the characterization trips has been accomplished using a variety of statistical methods including, but not be limited to, ANOVA, linear and multiple regression, t-tests and spatial statistics. The purpose of these analyses was to detect significant differences in the catch-per-unit-effort (CPUE) of selected bycatch species by season, location and depth. No statistical analysis of the data is presented in this initial paper, and all general comparisons will be only in weight values.

RESULTS AND DISCUSSION

Over the past five years (February 1992 through October 1995) a total of 3653 sea-days of sampling effort has been achieved by NMFS observers (1359 days) and non-NMFS observers (2294 days) in the Gulf of Mexico and along the east coast of the United States of America. Most of the effort occurred in waters

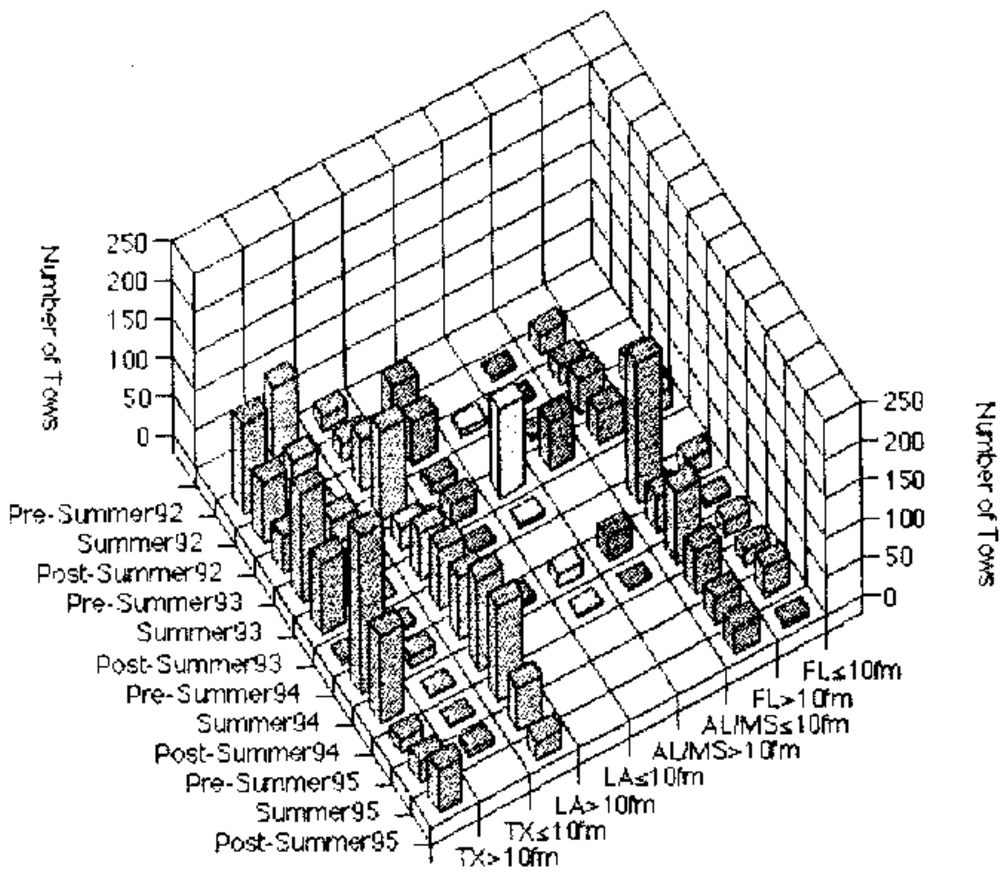

Fig. 1. Number of observed tows depicted by season, location and depth. (TX - Texas, LA - Louisiana, AL/MS - Alabama / Mississippi, FL - Florida).

off Texas (1090 days) and Louisiana (943 days), followed by Florida (686 days) and Alabama–Mississippi (160 days). These sea-days were accomplished during 544 trips, varying in length from 1 to 54 days. From these sea days, bycatch data have been collected from 5045 individual tows, with several hundred different species being documented from the trawls. The majority of tows sampled occurred in the offshore waters (>10 fm) off Louisiana and Texas (Fig. 1). The Alabama–Mississippi area had the fewest sampled tows. This pattern, however, is indicative of the commercial shrimping effort in the areas, since most of the effort and catch is also from the Louisiana and Texas offshore areas.

When all tows collected in the Gulf of Mexico were combined for analysis, the statistics revealed that on the average about 27 kg of organisms per hour are taken during trawling operations. Analysis of the composition of the organisms showed that about 68% of the catch by weight is composed of finfish, 16% by commercial shrimp species (brown shrimp, *Penaeus aztecus*, white shrimp, *P. setiferus*, pink shrimp, *P. duorarum*, seabobs, *Xiphopenaeus kroyeri*, sugar shrimp, *Trachypenaeus constrictus*, and rock shrimp, *Sicyonia brevirostris*), 13% by non-commercial shrimp crustaceans and 3% by non-crustacean invertebrate species. The top 10 species caught in shrimp trawls in the Gulf of Mexico by weight were longspine porgy (15%, *Stenotomus caprinus*), brown shrimp (9%), Atlantic croaker (9%, *Micropogonias undulatus*), inshore lizardfish (6%, *Synodus foetens*), pink shrimp (3%), Gulf butterfish (3%, *Peprilus burti*), lesser blue crab (2%, *Callinectes similis*), white shrimp (2%), longspine swimming crab (2%, *Portunus spinicarpus*) and rock shrimp (2%). The other 47% of the catch not accounted for by these ten species was composed of several hundred finfish and invertebrate species.

Shrimp trawl catch-per-hour averages for each location and depth zone are presented in Figure 2. In each case the offshore zone had a lower catch rate than that of the nearshore area for the same location. The Alabama–Mississippi area had the highest overall combined (nearshore + offshore) catch rate, while

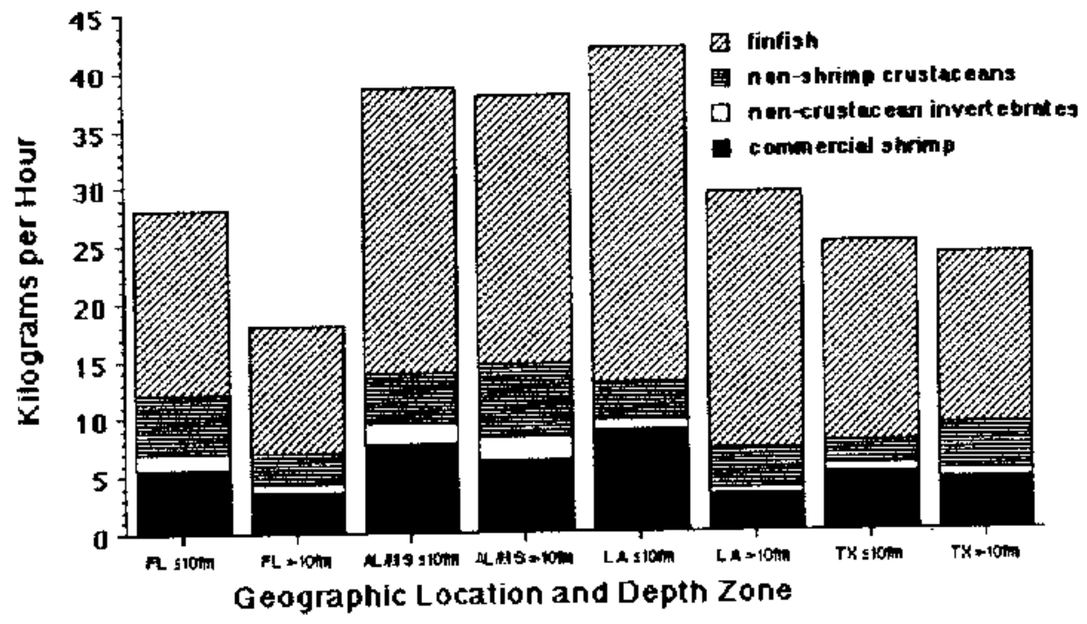

Fig. 2. Average kilograms of organisms per hour by location and depth. (TX - Texas, LA - Louisiana, AL/MS - Alabama / Mississippi, FL - Florida).

the Louisiana nearshore area had the greatest catch rate for a single area. Offshore Florida had the lowest single area catch rate. In each area, the lowest catch rates were for non-crustacean invertebrates, followed by non-shrimp crustaceans and commercial shrimp. Finfish had the highest catch rates in all locations and depths. On the average, about four kg of finfish are taken as bycatch for every one kg of commercial shrimp harvested in the trawl. This is less than the 10:1 finfish to shrimp weight ratio reported in the early 1980s (Pellegrin *et al.* 1981). The use of TEDs in shrimp trawls can probably explain some of the decrease (Renaud *et al.* 1990), while overall reduction in some finfish populations in the Gulf of Mexico may also be contributing to the change in the ratio (Chittenden and McEachran 1975; Nichols *et al.* 1990).

In the Florida nearshore area the iridescent swimming crab (*Portunus gibbesii*) comprised 11% of the average weight in a typical trawl, followed by the leopard searobin (*Prionotus scitulus*) at 6% and the sand perch (*Diplectrum formosum*) at 6%. In the Florida offshore area the blotched swimming crab (*Portunus spinimanus*) constituted the greatest average weight at 9%, followed by the shoal flounder (*Syacium gunteri*) at 7% and the inshore lizardfish at 5%. In the Alabama–Mississippi nearshore area the Atlantic croaker made up the greatest percentage of the catch in a typical trawl at 32%, followed by the sand seatrout (*Cynoscion arenarius*) and the lesser blue crab each at 7%. In the Alabama–Mississippi offshore area the longspine porgy represented the species with the greatest overall average weight percentage in the catch at 14%, followed by the inshore lizardfish and the Atlantic croaker, each at 5%.

In Louisiana, the Atlantic croaker represented the greatest percentage of the nearshore catch at 18%, with Gulf menhaden (*Brevoortia patronus*) at 9% and longspine porgy at 8%. In the offshore waters, longspine porgy was greatest at 20%, followed by the inshore lizardfish and the Atlantic croaker, each at 10%. Catch composition in the Texas area was very similar to that for Louisiana. The nearshore catch in Texas was dominated by Atlantic croaker at 15%, followed by Gulf butterfish at 14% and longspine porgy at 6%. In the offshore area the longspine porgy represented the greatest component of the catch at 25%, followed by the Atlantic croaker at 6% and the inshore lizardfish at 6%. It can be observed from the data that on average the Atlantic croaker was the bycatch species that was represented

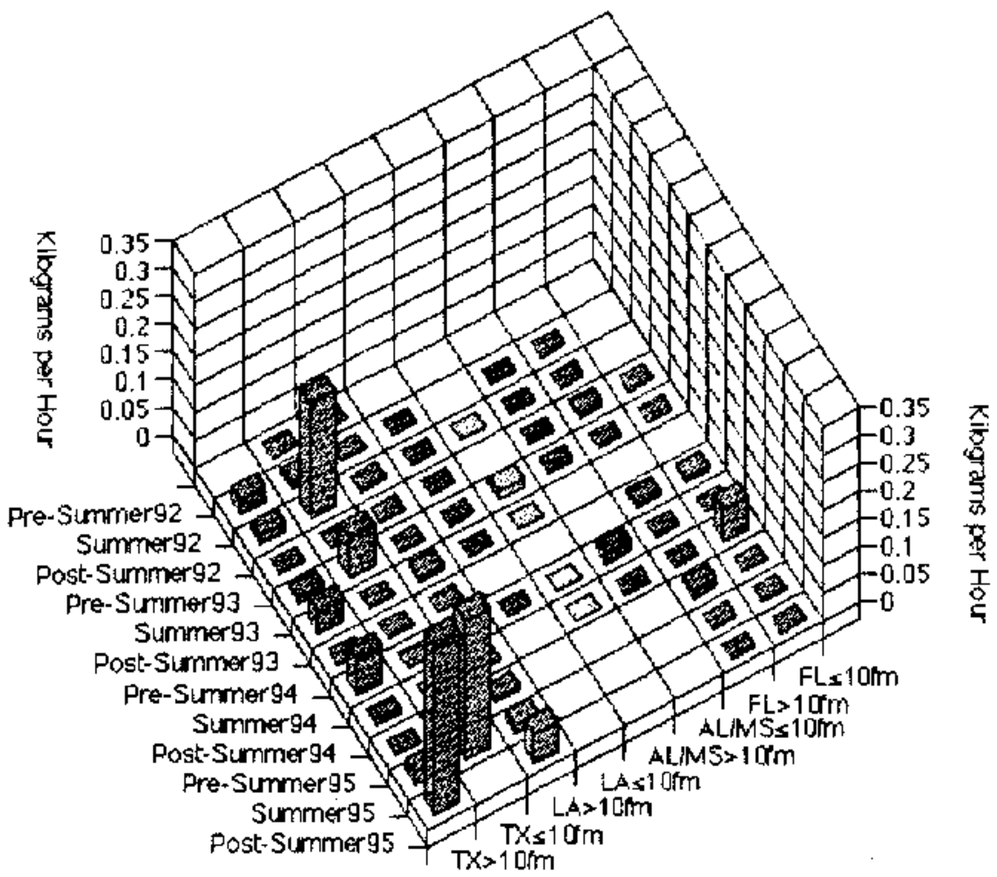

Fig. 3. Average kilograms of king mackerel (*Scomberomorus cavalla*) per hour by season, location and depth. (TX - Texas, LA - Louisiana, AL/MS - Alabama / Mississippi, FL - Florida).

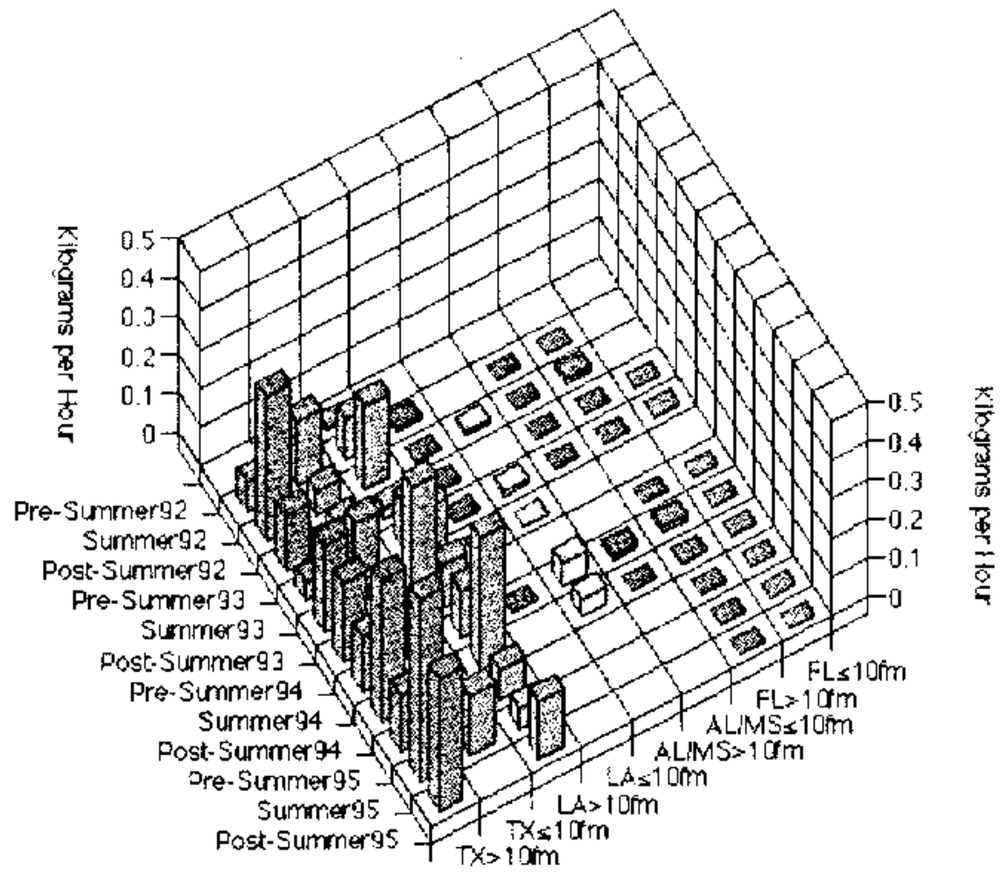

Fig. 5. Average kilograms of red snapper (*Lutjanus campechanus*) per hour by season, location and depth. (TX - Texas, LA - Louisiana, AL/MS - Alabama / Mississippi, FL - Florida).

most frequently in the nearshore trawls for most areas, while the longspine porgy typically dominated the offshore trawls.

Although groundfish species make up the majority of the bycatch taken in shrimp trawls, several species that represent only minor components of the total bycatch have received a great deal of attention because of their commercial and recreational importance, and the potential for significant impacts on their population abundance. Three of these species are king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*) and red snapper (*Lutjanus campechanus*). Catches of these three species are far less than those observed for some of the common groundfish species. The highest catch rates for king mackerel have been recorded in the Texas area, typically during the summer seasons nearshore and the post-summer seasons offshore (Fig. 3), with none of the CPUE values over 0.35 kg per hour. On average, king mackerel had a median length of 232 mm. The highest catch rates for Spanish mackerel occurred in the nearshore waters off Texas, Louisiana and Alabama–Mississippi (Fig. 4). A very high catch rate (for Spanish mackerel) was noted during the pre-summer season in 1993 off Louisiana, but most values are below 0.5 kg per hour. On the average, Spanish mackerel had a median length of 179.5 mm. Red snapper are rarely caught in the Florida and Alabama–Mississippi areas (Fig. 5). Highest catch rates are experienced in the offshore waters of Texas and Louisiana during summer and post-summer seasons. None of the catch rates exceeded 0.5 kg per hour. On the average, red snapper had a median length of 109 mm.

Overall the shrimp trawl bycatch characterization research programme has yielded a great deal of important information on catch rates for various invertebrate and finfish species in the US Gulf of Mexico. Estimates of the magnitude of the bycatch for a particular species can be determined by extrapolating these average catch rates with average hours of shrimping effort in the same depth, location and season. However, these estimated values must be used in the context of a stock assessment to determine the actual impacts that shrimp trawling activities have on a particular population.

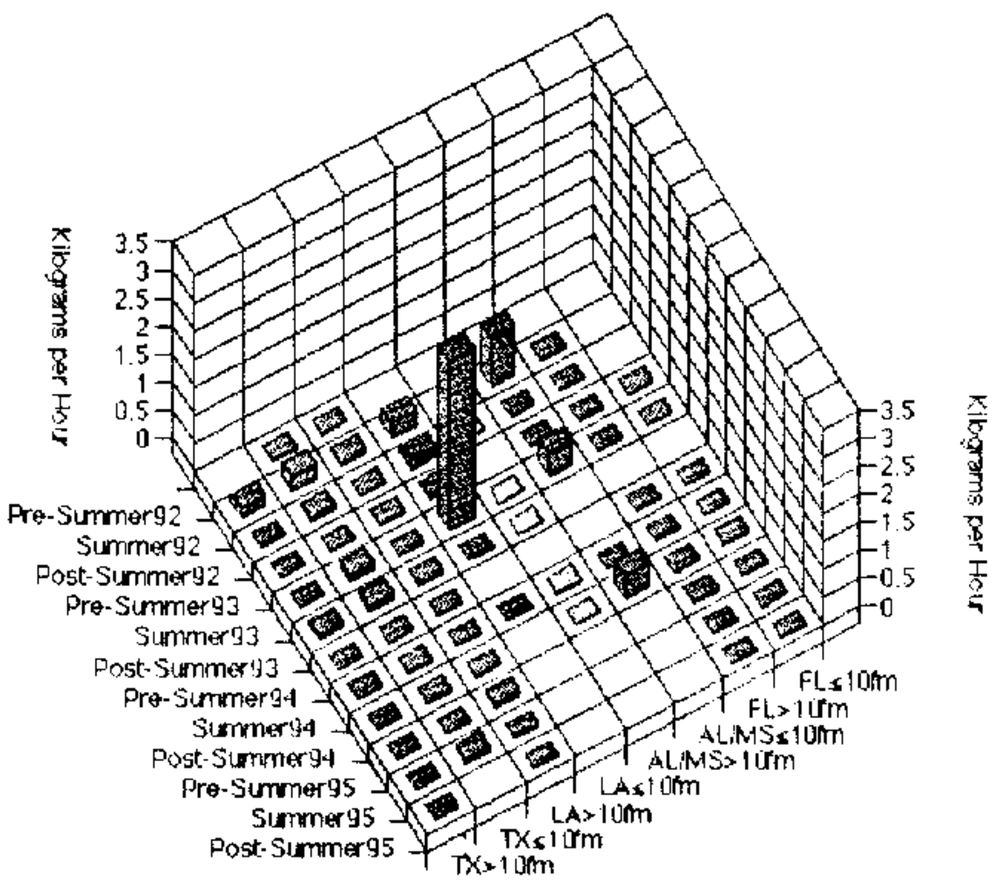

Fig. 4. Average kilograms of Spanish mackerel (*Scomberomorus maculatus*) per hour by season, location and depth. (TX - Texas, LA - Louisiana, AL/MS - Alabama / Mississippi, FL - Florida).

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